Prevalence of the Metabolic Syndrome in American Adolescents

Findings From the Third National Health and Nutrition Examination Survey

Sarah D. de Ferranti, MD, MPH; Kimberlee Gauvreau, ScD; David S. Ludwig, MD; Ellis J. Neufeld, MD, PhD; Jane W. Newburger, MD, MPH; Nader Rifai, PhD

Background—Metabolic syndrome (MetS) is defined by the Third Report of the Adult Treatment Panel (ATP III) using criteria easily applied by clinicians and researchers. There is no standard pediatric definition.

Methods and Results—We defined pediatric MetS using criteria analogous to ATP III as ≥3 of the following: (1) fasting triglycerides ≥1.1 mmol/L (100 mg/dL); (2) HDL <1.3 mmol/L (50 mg/dL), except in boys aged 15 to 19 years, in whom the cutpoint was <1.2 mmol/L (45 mg/dL); (3) fasting glucose ≥6.1 mmol/L (110 mg/dL); (4) waist circumference >75th percentile for age and gender; and (5) systolic blood pressure >90th percentile for gender, age, and height. MetS prevalence in US adolescents was estimated with the Third National Health and Nutritional Survey 1988 to 1994. Among 1960 children aged ≥12 years who fasted ≥8 hours, two thirds had at least 1 metabolic abnormality, and nearly 1 in 10 had MetS. The racial/ethnic distribution was similar to adults: Mexican-Americans, followed by non-Hispanic whites, had a greater prevalence of MetS compared with non-Hispanic blacks (12.9%, [95% CI 10.4% to 15.4%]; 10.9%, [95% CI 8.4% to 13.4%]; and 2.5%, [95% CI 1.3% to 3.7%], respectively). Nearly one third (31.2% [95% CI 28.3% to 34.1%]) of overweight/obese adolescents had MetS.

Conclusions—Our definition of pediatric MetS, designed to be closely analogous to ATP III, found MetS is common in adolescents and has a similar racial/ethnic distribution to adults in this representative national sample. Because childhood MetS likely tracks into adulthood, early identification may help target interventions to improve future cardiovascular health. (Circulation. 2004;110:2494-2497.)

Key Words: metabolic syndrome ■ pediatrics ■ risk factors

The metabolic syndrome (MetS), also called insulin resistance syndrome, has been described in many ways, in part owing to the lack of a “gold standard” diagnostic test. The Adult Treatment Panel III (ATP III) defines adult MetS as 3 or more of the following abnormalities: hypertriglyceridemia, low HDL, high fasting glucose, excessive waist circumference, and hypertension, on the basis of associations with adverse cardiovascular outcomes derived from large research trials.1 Adults with MetS are at greater risk for cardiovascular disease2 and diabetes mellitus.3 Ford et al,4 using the Third National Health and Nutritional Survey (NHANES III), estimated the syndrome affected 25% of US adults.

The MetS has not been well characterized in children and adolescents in terms of criteria, prevalence, or clinical implications, although studies have examined MetS abnormalities.5,6 We propose a definition of MetS in adolescents based closely on the ATP III1 and, using NHANES III data, describe its prevalence in US children aged 12 to 19 years.

Methods

ATP III defines adult MetS as 3 or more of the criteria described in the Table. To generate a definition appropriate for children aged 12 to 19 years, we extrapolated from adult criteria. Triglyceride (TG) and HDL cutpoints were taken from equivalent pediatric percentiles.7 We defined hyperglycemia using the ATP III cutpoint. ATP III uses waist circumference as a measure of central obesity, and percentiles for age and gender have been most associated with central obesity in children across genders and races; therefore, we used percentiles comparable to the adult male cutpoint of the 70th percentile.9 Because normal pediatric blood pressure varies significantly, we used the National Heart, Lung, and Blood Institute’s recommended cutpoint of >90th percentile for age, gender, and height.10

NHANES III is a national data set collected between 1988 and 1994, weighted to represent the population of noninstitutionalized US civilians not living on Indian reservations and aged 2 years and...
older. It uses a multistage, stratified sampling design and has been well described. The present sample was drawn from children aged 12 to 19 years who underwent physical examinations and fasted before blood testing.

### Statistical Methods

For the 1960 children aged 12 to 19 years who participated in the examination of the NHANES III survey and fasted for at least 8 hours, the prevalence of MetS was calculated overall and by gender, age group, and race or ethnicity. Because of the survey’s complex sampling design, estimates and standard errors were calculated in Stata with the sampling weights provided, to be representative of the civilian, noninstitutionalized US population. Sample weights are adjusted for nonresponse. For estimates of prevalence, subjects with missing information on MetS criteria were assumed not to have met that criterion. A second set of estimates was calculated solely for subjects with nonmissing data for all 5 criteria. MetS prevalence was also estimated in the subgroup of adolescents with body mass index ≥85th percentile for age and gender.

### Results

Low HDL, hypertriglyceridemia, and central obesity were common among the present sample, whereas hyperglycemia and hypertension were infrequent (Figure 1). As in adults, hypertriglyceridemia and low HDL were most common among non-Hispanic whites and least common among non-Hispanic blacks, whereas Mexican-Americans had the greatest prevalence of high waist circumference (data not shown). For estimates of prevalence, subjects with missing information on MetS criteria were assumed not to have met that criterion. A second set of estimates was calculated solely for subjects with nonmissing data for all 5 criteria. MetS prevalence was also estimated in the subgroup of adolescents with body mass index ≥85th percentile for age and gender.

### Discussion

Using a pediatric definition based closely on ATP III, we found the prevalence of MetS in US children aged 12 to 19 years was approximately 1 in 10. In overweight/obese children, a notable 1 in 3 had MetS. Moreover, two thirds of all adolescents had at least 1 metabolic abnormality. Our findings are consistent with research in young adults, in whom the 10-year incidence of MetS was 8% to 12% in the nonobese and 34% to 41% in the obese, although this definition used more extreme lipid cutoffs and body mass index instead of waist circumference. Our results are not surprising in view of the high and rising rates of obesity and type 2 diabetes mellitus in US children.

Pediatric researchers have investigated individual metabolic abnormalities that increase cardiovascular risk and found they track from childhood to adulthood, leading one to suspect MetS might also track into adulthood.

### Table: Adult and Proposed Pediatric Definitions of MetS

<table>
<thead>
<tr>
<th>Definition</th>
<th>Adult Definition*</th>
<th>Percentiles</th>
<th>Proposed Pediatric Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertriglyceridemia</td>
<td>≥1.65 mmol/L</td>
<td>75th (male); 85th (female)</td>
<td>≥1.1 mmol/L</td>
</tr>
<tr>
<td>Low HDL</td>
<td>&lt;1.04 mmol/L (men); &lt;1.3 mmol/L (women)</td>
<td>40th</td>
<td>HDL &lt;1.3 mmol/L (boys aged 15–19 years, &lt;1.17 mmol/L)</td>
</tr>
<tr>
<td>High fasting glucose</td>
<td>≥6.1 mmol/L</td>
<td>NA</td>
<td>≥6.1 mmol/L</td>
</tr>
<tr>
<td>Central obesity (waist circumference)</td>
<td>&gt;102 cm (men); &gt;88 cm (women)</td>
<td>72nd (male); 53rd (female)</td>
<td>&gt;75th percentile for age and gender</td>
</tr>
<tr>
<td>Hypertension</td>
<td>SBP ≥130 mm Hg; DBP ≥80 mm Hg</td>
<td>NA</td>
<td>&gt;90th percentile for age, gender, and height</td>
</tr>
</tbody>
</table>

*ATP III. To convert SI to conventional units, divide mmol/L by 0.0113 for triglycerides, 0.0259 for HDL, and 0.0555 for glucose.
childhood obesity predicts the development of MetS in adulthood.\textsuperscript{15} MetS has an important immediate impact: adolescents with MetS have lower exercise capacity than obese and normal-weight controls.\textsuperscript{16} Obesity alone increases the risk of hypertension, cholecystitis, and slipped capital femoral epiphysis and is associated with psychosocial symptoms in children.\textsuperscript{17}

Diverse definitions of pediatric MetS have been used in various populations. The Quebec family cohort study\textsuperscript{18} used skinfold measurements and mean blood pressure, criteria more cumbersome for the primary pediatrician and less closely based on ATP III than the present definition. The Taipei Children Heart Study\textsuperscript{18} used its own population distribution for cutpoints. A Hungarian study defined MetS by more extreme lipid cutpoints, body fat measurements instead of waist circumference, and 24-hour blood pressure monitoring. In a high-risk US population of obese children, 39% had MetS when defined by body mass index instead of waist circumference, lipid levels \textges;95th percentile (or \textles;5th percentile for HDL), and oral glucose tolerance testing.\textsuperscript{19} The MetS definition given by Cook et al,\textsuperscript{6} based on 1992 National Cholesterol Education Program guidelines and devised before ATP III and wide recognition of MetS, uses more restrictive lipid and abdominal circumference cutpoints, which leads to lower prevalence estimates in adolescents of \textapproxeq;4%. Translating their definition to pediatric percentiles, an HDL level of 40 mg/dL represents the 10th to 25th percentile in boys and 10th to 15th percentile in girls, lower than the adult 40th percentile. The higher triglyceride cutpoint of 110 mg/dL represents the 85th to 95th pediatric percentile, also higher than the adult 75th to 85th percentile. The abdominal circumference cutpoint of the 90th percentile is higher than the 75th percentile used in the present study. In contrast to other criteria, our pediatric definition was based closely on the more inclusive ATP III adult criteria, considering the effects of age, gender, and puberty, and therefore captures a larger population of adolescents.

Our study should be interpreted in light of its limitations. The primary limitation is that study outcomes depend on our definition of MetS, a problem inherent to any extrapolation of the adult definition to a pediatric population. We used standard cholesterol cutpoints that form the basis for ATP III, and National Cholesterol Education Program/American Academy of Pediatrics, guidelines. Cholesterol levels, particularly HDL levels in males, are affected by puberty,\textsuperscript{20} yet pediatric norms from Lipid Research Clinic data are available by age, not by Tanner stage. Because these normative data were published in 1979 and may not reflect contemporary earlier puberty rates, we may have overestimated the number of boys with abnormally low HDL. However, decreases in the age of puberty have primarily affected girls, not boys, which minimizes this effect. We used waist circumference as a convenient surrogate for visceral obesity, which is associated with insulin resistance, the likely pathophysiological underpinning of MetS. Waist circumference is a less accurate but more practical and lower-risk indicator of visceral obesity than abdominal CT or MRI, is the method used by ATP III, and is available in NHANES III. Fat distribution is affected differentially by puberty in girls and boys; we attempted to control for this using age- and gender-based waist circumference percentiles. The present study is also limited by the database. Although NHANES is highly representative of most of the United States, American Indian reservations are not included in the survey. The rate of obesity and type 2 diabetes mellitus is particularly high in some American Indian populations\textsuperscript{21}; one would expect higher MetS rates in these groups.

The impact of these data may be far-reaching. In adults, MetS correlates with increased rates of type 2 diabetes mellitus and cardiovascular disease.\textsuperscript{2,3} Practitioners should be aware of the clustering of metabolic abnormalities in children, and affected children should receive risk-reducing interventions. Understanding the prevalence of pediatric MetS may foster interventions and research; further investigation could better illuminate its pathophysiology and relationship to cardiovascular disease.

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References

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